

On the non-probabilistic nature of thermodynamic processes: Fundamental to a non-statistical formulation of thermodynamics

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Abstract

His paper proposes a reevaluation of the fundamental nature of thermodynamics, challenging the prevailing view that attributes macroscopic behavior exclusively to statistical fluctuations of microscopic systems. Through a critical analysis of conservation laws and systems dynamics, it argues that the probabilistic nature observed in conventional thermodynamics is not an intrinsic property of matter at a fundamental level, but rather a consequence of an incomplete description of the microscopic state. The possibility of a deterministic formulation is examined, exploring the implications of integrating a complete causal dynamics that dispenses with overall averages, suggesting that the "arrow of time" and entropy could be emergent manifestations of a more precise underlying dynamic structure and not merely the result of chance.

Keywords: thermodynamics, radiation, black body, Max Planck, Ludwig Boltzmann

1. Introduction

Since the consolidation of statistical mechanics by Boltzmann and Gibbs, it has been assumed as a scientific dogma that thermodynamics is essentially a science of large numbers. Under this paradigm, the laws of thermodynamics, including the second law, are interpreted as statistical truths: they are laws that emerge due to ignorance about the individual trajectories of the particles that make up a system.

However, this interpretation raises long-standing conceptual dilemmas, such as Loschmidt's paradox (the temporal reversibility of microscopic laws versus macroscopic irreversibility) and the ontological nature of probability in physical systems. ¿Is randomness an inherent characteristic of the microscopic universe, or is it simply an epistemic tool we use to manage complexity?

This work is based on the hypothesis that the dependence on statistical formalism in thermodynamics is not an unavoidable physical limitation, but rather a methodological choice. Throughout this research, we will explore the potential of a non-statistical microscopic thermodynamics, grounded in the dynamics of individual systems. We will analyze yes, by overcoming the limitations of measurement and access to complete information of the microstates, it is possible to derive the laws of thermodynamics through causal dynamics,

thus eliminating the need to resort to ensemble averages to explain the stability of equilibrium states.

2. Deduction of the radiation wave function

According to thermodynamics at the macroscopic level:

$$dS = \frac{d\varepsilon}{T} \quad [1] \quad (1)$$

From here, integrating both sides and since T is constant:

$$S = \frac{\varepsilon}{T} \quad (2)$$

Equality (2) can be reinscribed as follow:

$$S = -k \ln e^{-\frac{\varepsilon}{kT}} \quad (3)$$

Either:

$$S = -k \ln \Psi \quad (4)$$

If we differentiate S with respect to ε we obtain (1)

3. Obtaining the Boltzmann distribution function

From formula (4):

$$\Psi = e^{-\frac{\varepsilon}{kT}} \quad (5)$$

Differentiating Ψ respect to ε :

$$\frac{d\Psi}{d\varepsilon} = -\frac{e^{-\frac{\varepsilon}{kT}}}{kT} \quad [2] \quad (6)$$

Equation (6) is what is called the Boltzmann distribution function obtain without any statistical method.

The minus sign cancels out because in obtaining the average energy, that distribution function is both above and below in the formula for that average energy.

$$\bar{\varepsilon} = \frac{\int_0^\varepsilon (kT - \varepsilon) \left(-\frac{e^{-\frac{\varepsilon}{kT}}}{kT} \right) d\varepsilon}{\int_0^\varepsilon \left(-\frac{e^{-\frac{\varepsilon}{kT}}}{kT} \right) d\varepsilon} = \frac{\varepsilon}{e^{\frac{\varepsilon}{kT}} - 1} \quad [2] \quad (7)$$

4. Conclusions

Thermodynamics is not a statistical process as some assume.

The function Ψ is the wave function of the electromagnetic radiation generated by the oscillations of electrons due to temperature T.

5. References

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